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Offshore Feeding by Gulls (*Larus*) at Ocean Fronts in the Northeast Gulf of Mexico

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OFFSHORE FEEDING BY GULLS (*Larus*) AT OCEAN FRONTS IN THE NORTHEAST GULF OF MEXICO

Oceanic fronts are regions of intensified physical and biological activity where marine organisms may aggregate to feed (Pingree *et al.*, 1974). Seabirds have been reported at fronts in several geographic locations (Brown, 1980), but the only account of seabirds associated with fronts in the Gulf of Mexico is a brief mention by J. Bird during a pelagic Christmas Bird Count off Louisiana (Newman, 1983). This paper suggests that a typically inshore-feeding seabird species, the Laughing Gull (*Larus atricilla*), may feed offshore at fronts in the Gulf of Mexico. Because gulls exhibit weak or negative affinities for similar fronts elsewhere (Haney and McGillivary, 1985a), the possibility of distinctive physical or biological conditions at Gulf fronts is discussed in relation to these other seabird-front associations. The objective of this study was to compare species composition of seabirds at a Gulf of Mexico front to seabird species composition at a front in the nearby South Atlantic Bight (Cape Hatteras, North Carolina to Cape Canaveral, Florida).

METHODS AND MATERIALS

Data on offshore feeding groups of gulls were obtained from the literature (Clapp *et al.*, 1983; Newman, 1983). Locations of offshore gull flocks were then compared to frontal positions as determined from satellite imagery {very high resolution radiometry (VHRR); Gulf Stream System Flow Charts, National Oceanic and Atmospheric Administration, Miami, Florida}. These charts showed the presence of ocean fronts as continuous lines where horizontal temperature gradients were $< 0.75\,^{\circ}C$ per kilometer. Fronts occurred between Loop Current and slope water, and between slope and shelf water.

Since Bird (Newman, 1983) reported numbers of seabirds additional to those at the front, the abundances of seabird species were first adjusted proportionately by using the same relative abundances listed for the entire count. Two-hundred thirty birds reported by Bird (Newman, 1983) were at or within a few kilometers of the front. The assumption that "few" was < 10 kilometers was made, and this distance used as a boundary in comparing the two frontal regions. Thus, the species proportions rather than absolute abundances were the statistically treated values.

Two statistical models were used to test for significant differences in species composition between the Gulf of Mexico and South Atlantic Bight frontal regions. A 2 X 9 contingency table was used to test for the independence of species' abundances and frontal region (Snedecor and Cochran, 1980). A 2 X 3 contingency table was used to test for the independence of the occurrences of seabird feeding guilds and frontal region. Unidentified seabird species were excluded from these chi-square analyses. Species in both regions were classified into guilds based on principal prey consumed (Ashmole, 1971; Ainley, 1977).

RESULTS

Satellite charts from winter (November to March) typically showed one or more fronts between the Loop Current and coastline of the northeast Gulf of Mexico. These fronts often extended from southern Louisiana to the west Florida shelf. The extent of frontal meandering and the front's proximity to

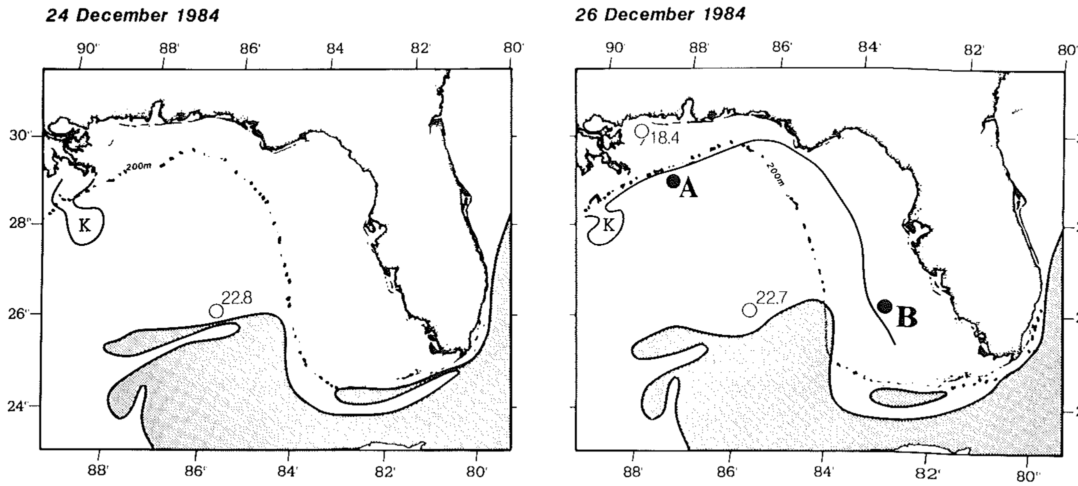

Figure 1. Typical oceanographic features during winter in the northeast Gulf of Mexico as detected by satellite radiometry (24 and 26 December 1984). Fronts are shown as continuous heavy lines and shading indicates warmer Loop and Florida Current water masses. The convolution of the front at 28°N, 90°W may represent the intrusion of colder, less-saline Mississippi River outflow. K = cold water mass. A = location of Bird's (Newman, 1983) gull observations at an oceanic front. B = location of offshore gull observations recorded in Clapp *et al.* (1983). Open circles and numbers refer to locations of measured sea surface temperature (°C).

Loop Current water varied, but was normally as depicted in Fig. 1.

Offshore gull flocks reported by Bird on 19 December 1982 occurred at an oceanic front (Newman, 1983), and this location corresponded to frontal positions detected by satellite imagery (Fig. 1). Clapp *et al.* (1983) noted hundreds of feeding *Larus atricilla* at location B (Fig. 1) during November 1974, also corresponding to a region of frontal activity.

The species composition of seabirds at the Gulf of Mexico front differed markedly from that at a similar front off Georgia in the South Atlantic Bight (Table 1). Both fronts occur over the continental shelf, and both occur between colder, more extensively-mixed shallow shelf water and warmer, current-influenced offshore water (Huh *et al.*, 1978; Haney and McGillivary, 1985a, Haney 1985). Gulls, primarily Laughing Gulls (*Larus atricilla*), dominated the seabird assemblage at the Gulf front, but phalaropes (*Phalaropus lobatus* and *P. fulicaria*) were dominant at the South Atlantic Bight front. Species composition between these two regions differed significantly ($\chi^2 = 732.24$, $p < 0.005$, df = 8).

When seabird species were classified into guilds, differences between the two regions were again apparent (Table 2). The South Atlantic Bight seabird-front assemblage consisted primarily (86%) of zooplanktivorous species. The Gulf front was numerically dominated by scavengers/piscivores (98%). Proportions of seabirds within guilds were significantly different between the two regions ($\chi^2 = 521.61$, $p < 0.005$, df = 3).

DISCUSSION

Differences between these two seabird-front associations were likely due to differences in the kinds of prey items aggregated at the fronts. The front in the South Atlantic Bight had high biomasses of larval Clupeiiform fish and the copepod *Eucalanus pileatus* (Haney and McGillivary, 1985a), thus attracting

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Table 1. Relative abundances (birds/hour) of seabird species compared at fronts in the northeast Gulf of Mexico (19 December 1982) and South Atlantic Bight (1 February 1984). Comparisons are based on counts made within 10 kilometers of the front at both locations. Effort was identical among species for both regions.

	Gulf of Mexico			South Atlantic Bight		
Species	N	Abundance	% of total N	N	Abundance	% of total N
Northern Gannet (*Sula bassanus*)	1	0.33	0.43	57	32.57	7.24
Magnificent Frigatebird (*Fregata magnificens*)	1	0.33	0.43	0	0.00	0.00
Red-necked Phalarope (*Phalaropus lobatus*)	0	0.00	0.00	240	137.14	30.50
Red Phalarope (*P. fulicaria*)	0	0.00	0.00	278	158.86	35.32
phalarope sp. (*Phalaropus*)	0	0.00	0.00	162	92.57	20.58
Laughing Gull (*Larus atricilla*)	122	40.67	53.04	0	0.00	0.00
Bonaparte's Gull (*L. philadelphia*)	0	0.00	0.00	39	22.29	4.96
Herring Gull (*L. argentatus*)	25	8.33	10.87	7	4.00	0.89
Black-legged Kittiwake (*Rissa tridactyla*)	0	0.00	0.0	4	2.29	0.51
gull sp. (*Larus*)	78	26.00	33.91	0	0.00	0.00
Royal Tern (*Sterna maxima*)	2	0.67	0.87	0	0.00	0.00
tern sp. (*Sterna*)	1	0.33	0.43	0	0.00	0.00
Total	230	76.67	99.98[a]	787	499.71	100.00

[a]Total less than 100% due to rounding error.

the zooplanktivorous phalaropes. The only common gull at this front, Bonaparte's Gull (*L. philadelphia*), feeds extensively on zooplankton in parts of its range (Baltz and Morejohn, 1977). The Laughing Gulls feeding offshore in the Gulf of Mexico were feeding on schooling baitfish (Clapp *et al.*, 1983). Fish may aggregate at ocean fronts to feed on other organisms (Sund *et al.*, 1981), for behavioral thermoregulation (Brandt and Wadley, 1981; Magnuson *et al.*, 1981), or because physical processes at fronts (convergence and advection) limit their dispersal (Olson and Backus, 1985). These fish aggregations may then in turn attract piscivorous seabirds like gulls. Laughing Gulls are common in both the Gulf of Mexico and South Atlantic Bight. It is thus unlikely that inter-regional variation in the species' abundance could alone account for the differences between frontal regions (Table 1). Large gull aggregations were never observed at fronts in the South Atlantic Bight during three years of monthly seabird surveys on the continental shelf.

Laughing Gulls usually feed inshore of the 20-m isobath (Rowlett, 1980), but may feed further offshore when particularly favorable opportunities occur, i.e., when prey concentrate at fronts. Seabirds are known to shift the location of their feeding in response to fronts. Normally inshore-feeding Northern Gannets (*Sula bassanus*) fed further offshore during seasons of frontal activity (Haney and McGillivary, 1985a).

Table 2. Differences in proportions (relative % of total abundances) of seabird guilds associated with fronts in the Gulf of Mexico and South Atlantic Bight. Guild classications derived from major prey consumed (Ashmole, 1971; Ainley, 1977).

Region	Planktivores	Piscivores	Scavengers/Piscivores
Gulf of Mexico	0.00	1.74	97.83
South Atlantic Bight	86.40	7.24	6.35

The physical processes at fronts or the locations of the front may influence aggregations of prey, thereby indirectly influencing seabird taxa and guilds feeding at the features (Table 3). Both upwelling (Yoder *et al.*, 1981) and downwelling (Olson and Backus, 1985) may occur at fronts. Biological processes at fronts are partially dependent upon the relative stability and persistence of the mixing processes. Food web development at fronts can be characterized by increased primary production (Iverson *et al.*, 1979), production or aggregation of primary consumers (Tranter *et al.*, 1983), and aggregation of secondary or tertiary consumers (Olson and Backus, 1985). The species composition of seabirds at fronts (Table 3) may partially reflect the nature of the food web. However, extrinsic factors such as the pool of available species and the seasonal dispersals and distribution of those species may also influence the seabird assemblages present at ocean fronts.

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Table 3. Comparisons of dominant species, food type, feeding method and front type in the Gulf of Mexico to other regions with seabird-front associations.

Region	Species	Food Type	Foraging method[a]	Front Type[b]	Reference
Gulf of Mexico	gulls (*Larus*)	mixed	scavenging	shallow sea or plume/riverine	Newman, 1983
Yucutan shelf	Sandwich tern (*Sterna sandvicensis*)	fish	plunge diving	plume/riverine	Brown, 1980
Bering Sea shelf (outer)	Northern Fulmar (*Fulmarus glacialis*)			shelf break	Schneider, 1982
	Fork-tailed Storm-Petrel (*Oceanodroma furcata*)	zooplankton	dipping/pattering		
Bering Sea shelf (mid)	murres (*Uria lamvia, U. aalge*)	fish	pursuit diving	shallow sea	Kinder *et al.*, 1983
South Atlantic Bight Shelf	phalaropes (*Phalaropus lobatus, P. fulicara*)	zooplankton	surface seizing	shallow sea	Haney and McGillivary, 1985a
Gulf Stream	Cory's Shearwater (*Calonectris diomeda*)	fish	surface seizing	boundary current	Haney and McGillivary, 1985b
Ross Sea	Antarctic Petrel (*Thalassoica antarctica*)	zooplanton/ cephalopods	contact dipping	shelf break	Ainley and Jacobs, 1981

[a]Terminology follows Ashmole (1971) and Ainley (1977).
[b]Terminology follows Bowman and Esaias (1978).

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